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Facius et al.

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(54) **COOLING TOWER AIR INLET AND DRAIN PAN**

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B01F 3/04 (2006.01)

(52) **U.S. Cl.** **261/72.1**; 261/119.1; 261/DIG. 11

(58) **Field of Classification Search** .... 261/29, 261/72.1, 109, 112.1, 119.1, DIG. 11
See application file for complete search history.

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(57) **ABSTRACT**

A mechanical draft cooling tower is provided. The cooling tower includes a direct cooling section having a plurality of fill sheets. Water is sprayed downwardly over the fill sheets and is collected in a collection sump. The collection sump includes two end walls, two side walls, a floor and a drain. The end walls are sloped at the floor intersection. The floor is sloped to a center section where the drain is located.

10 Claims, 3 Drawing Sheets

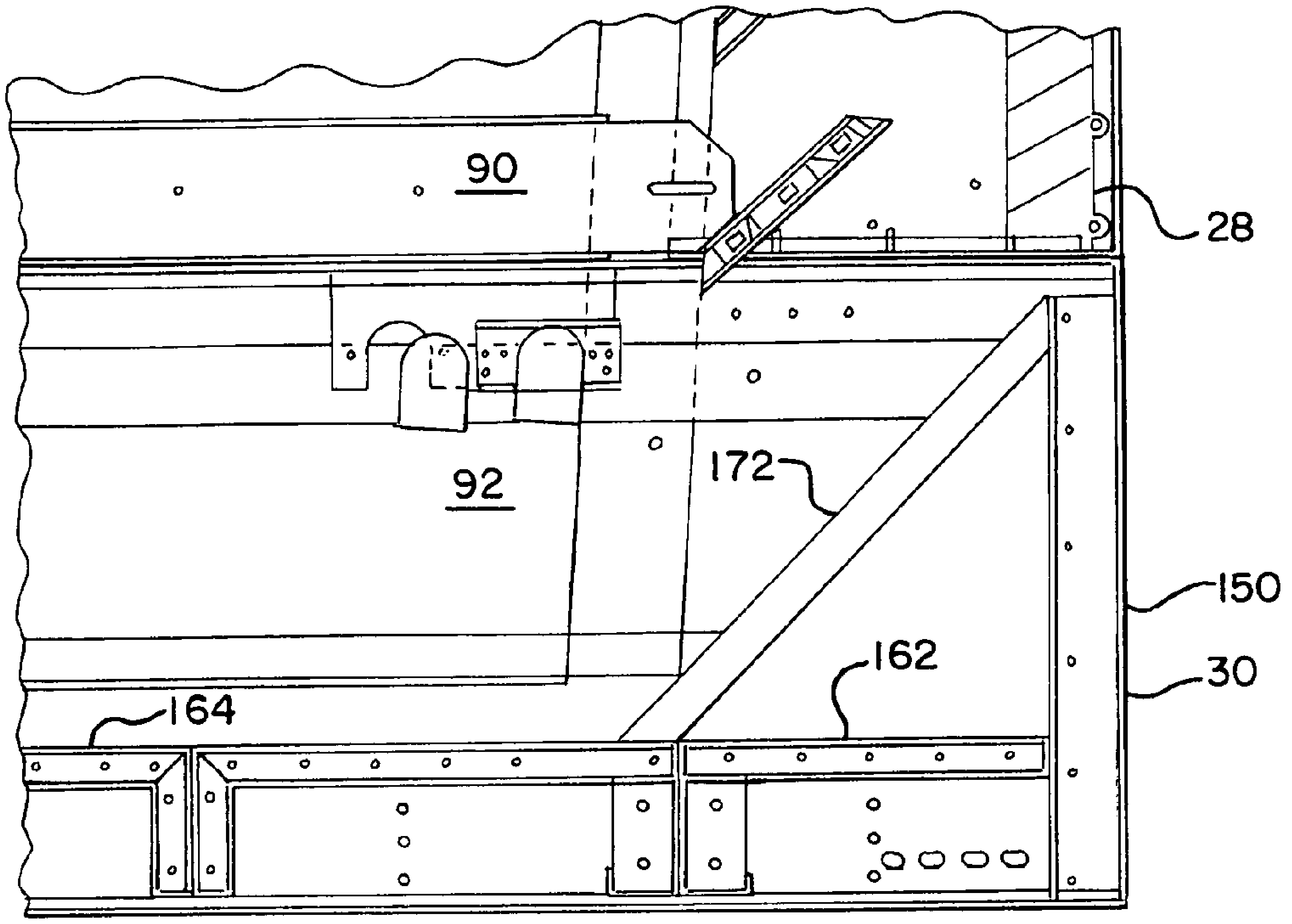

FIG. 1

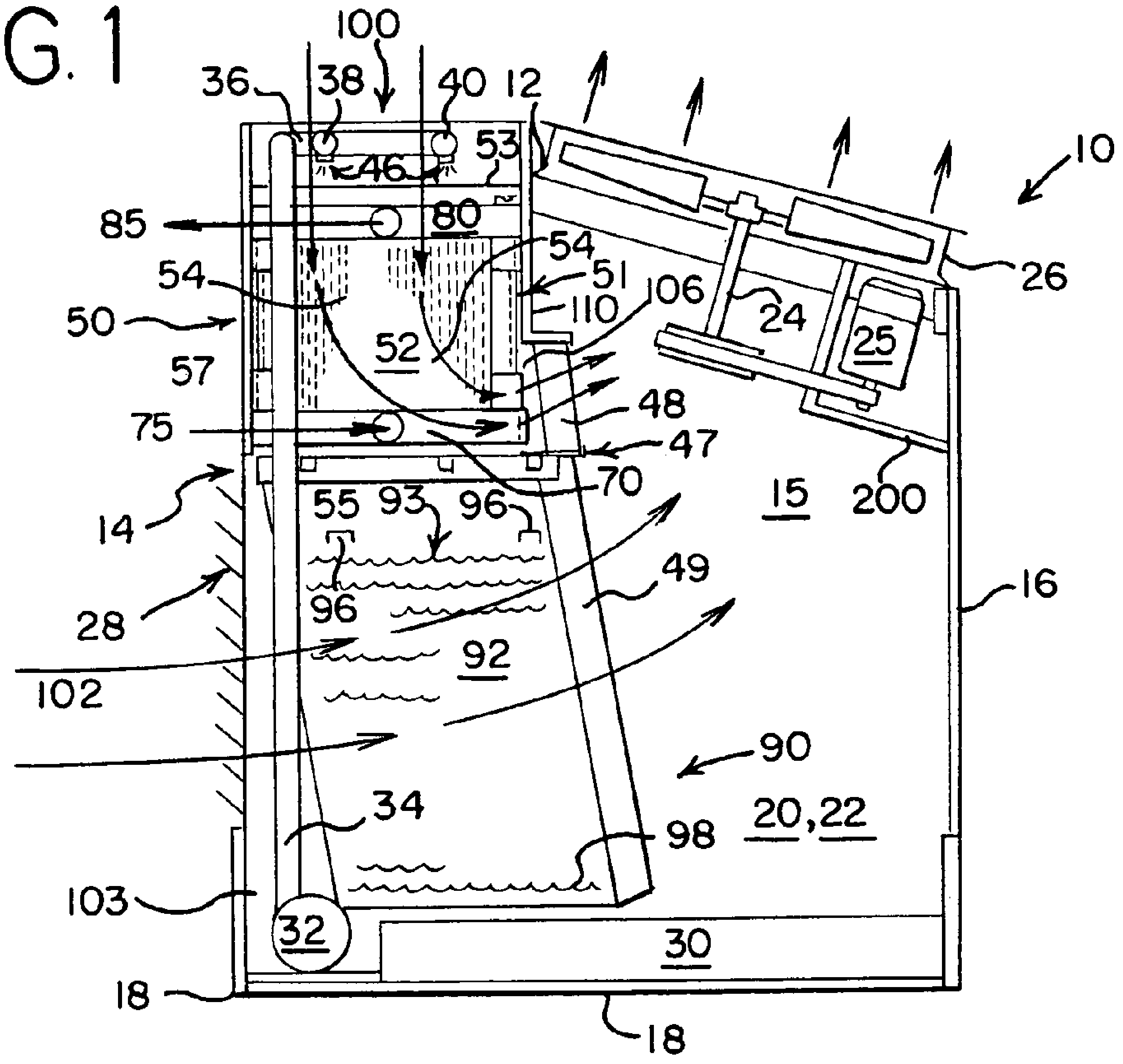
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FIG. 2

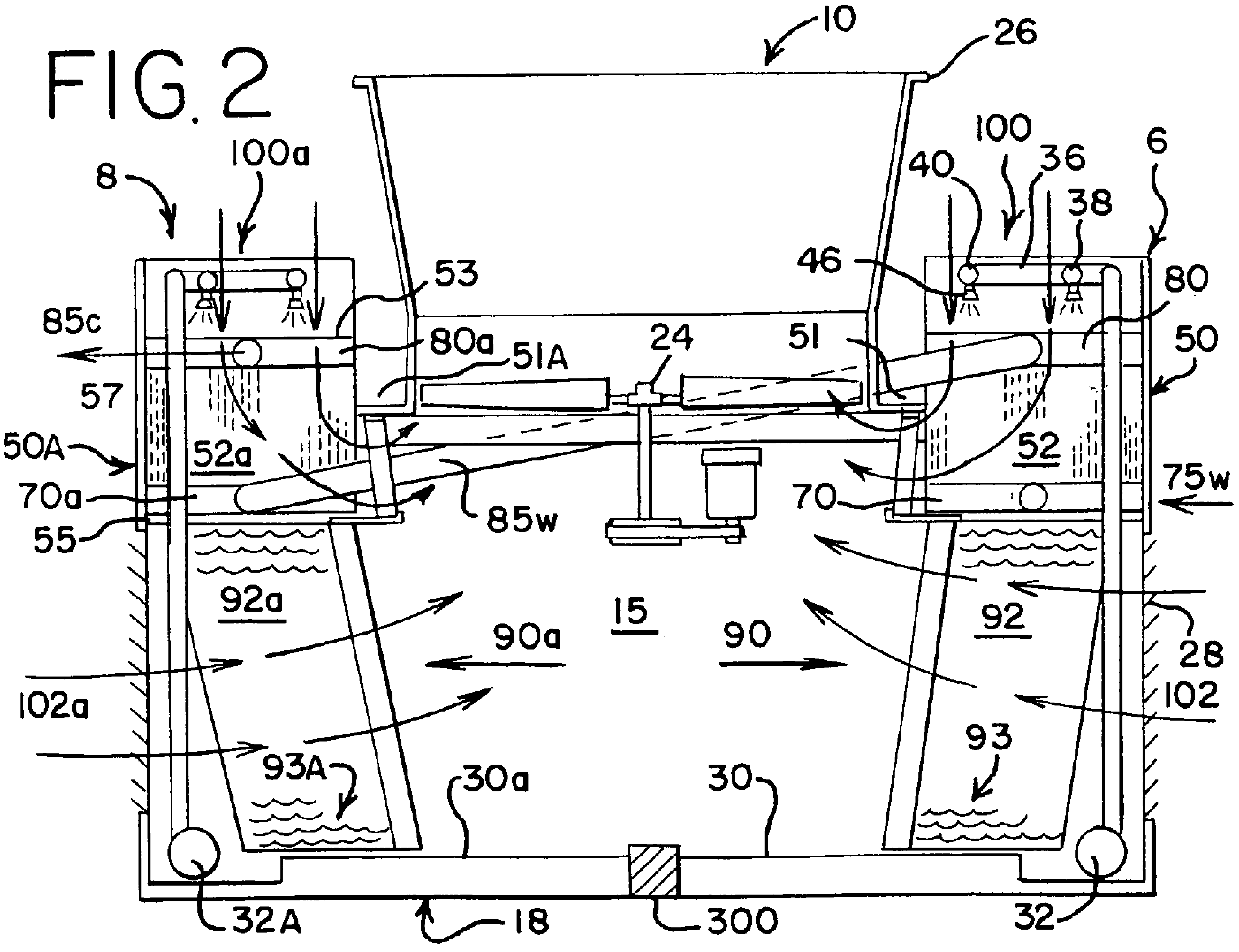
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FIG. 3

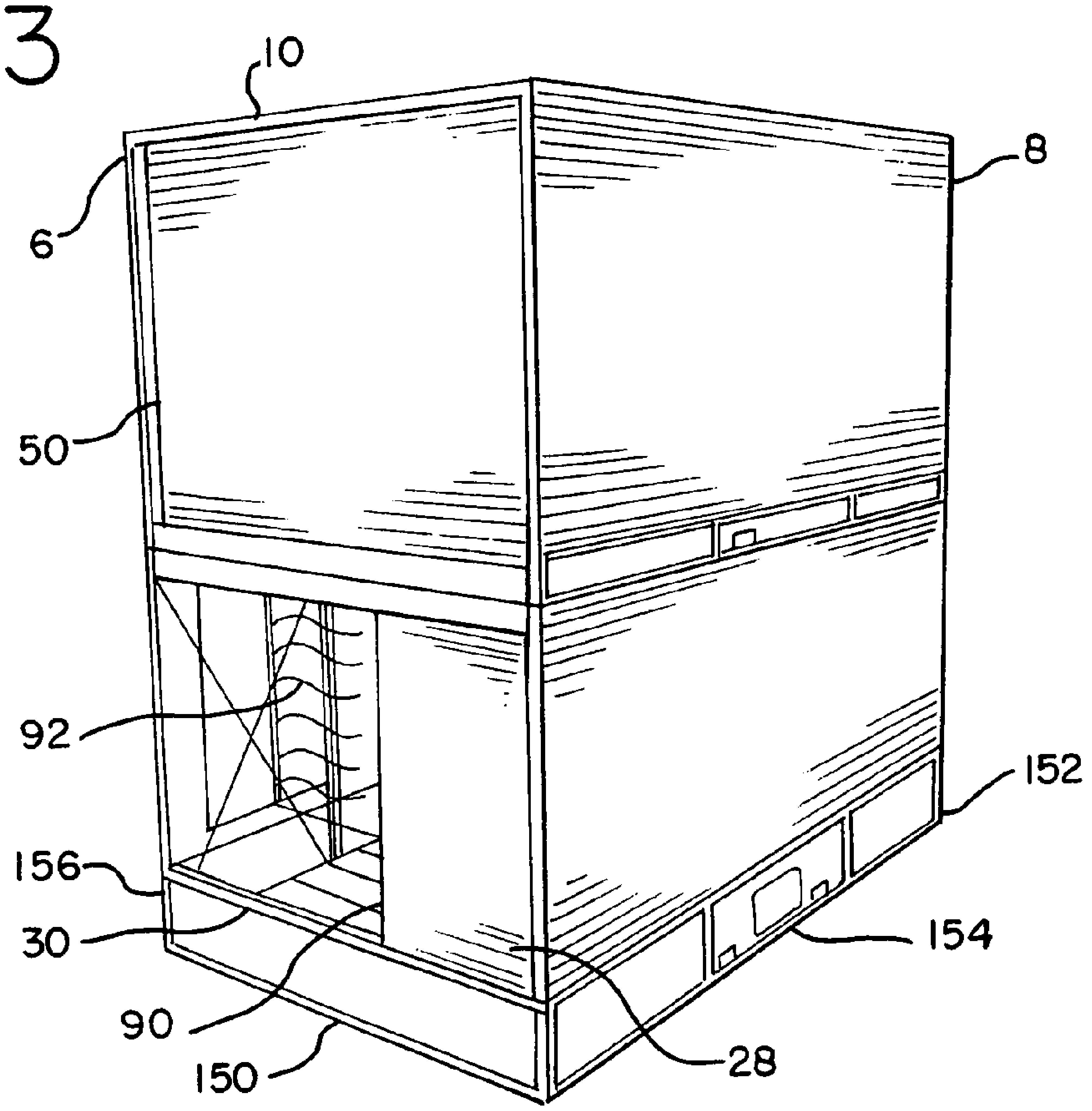
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FIG. 4

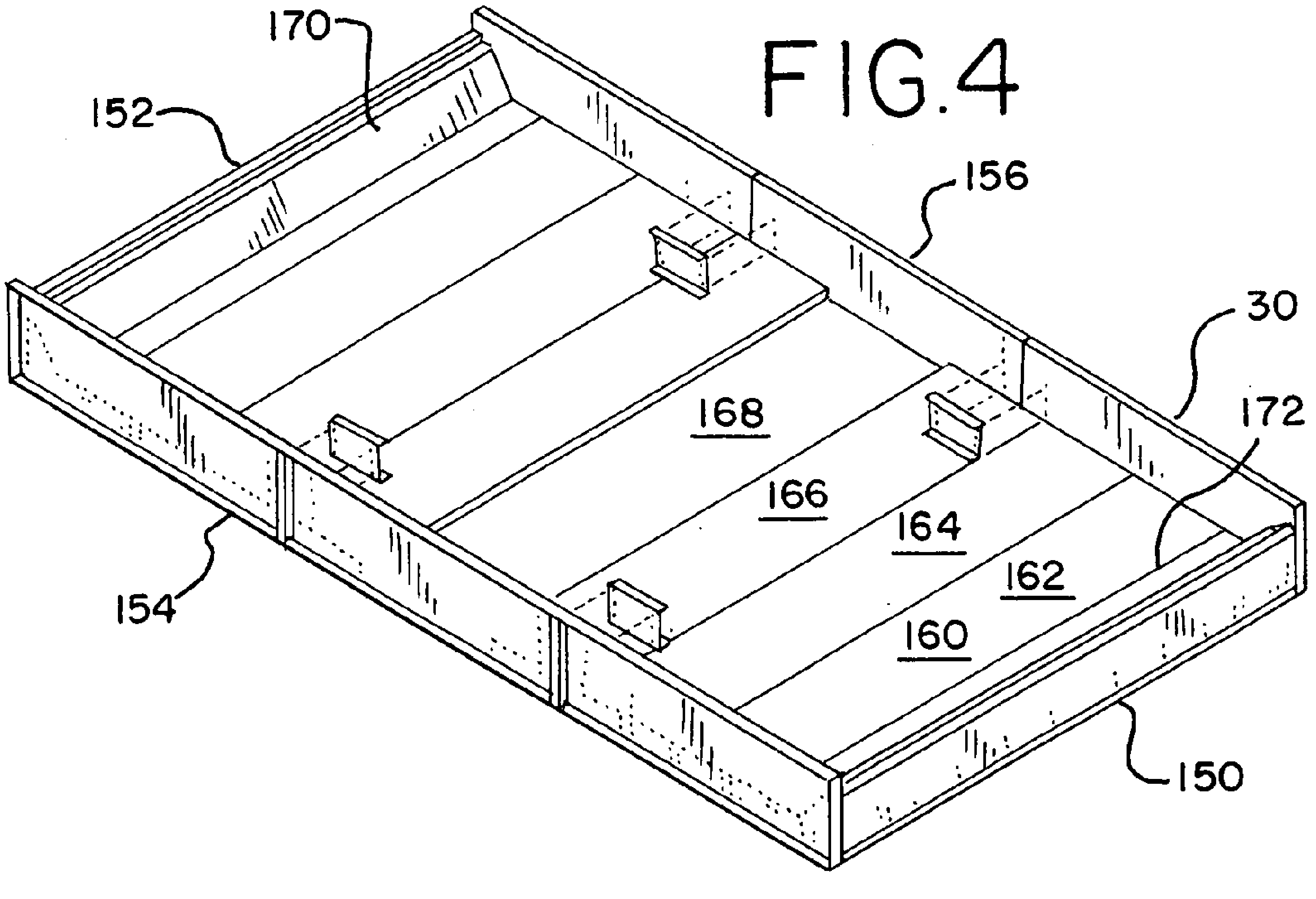
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FIG. 5

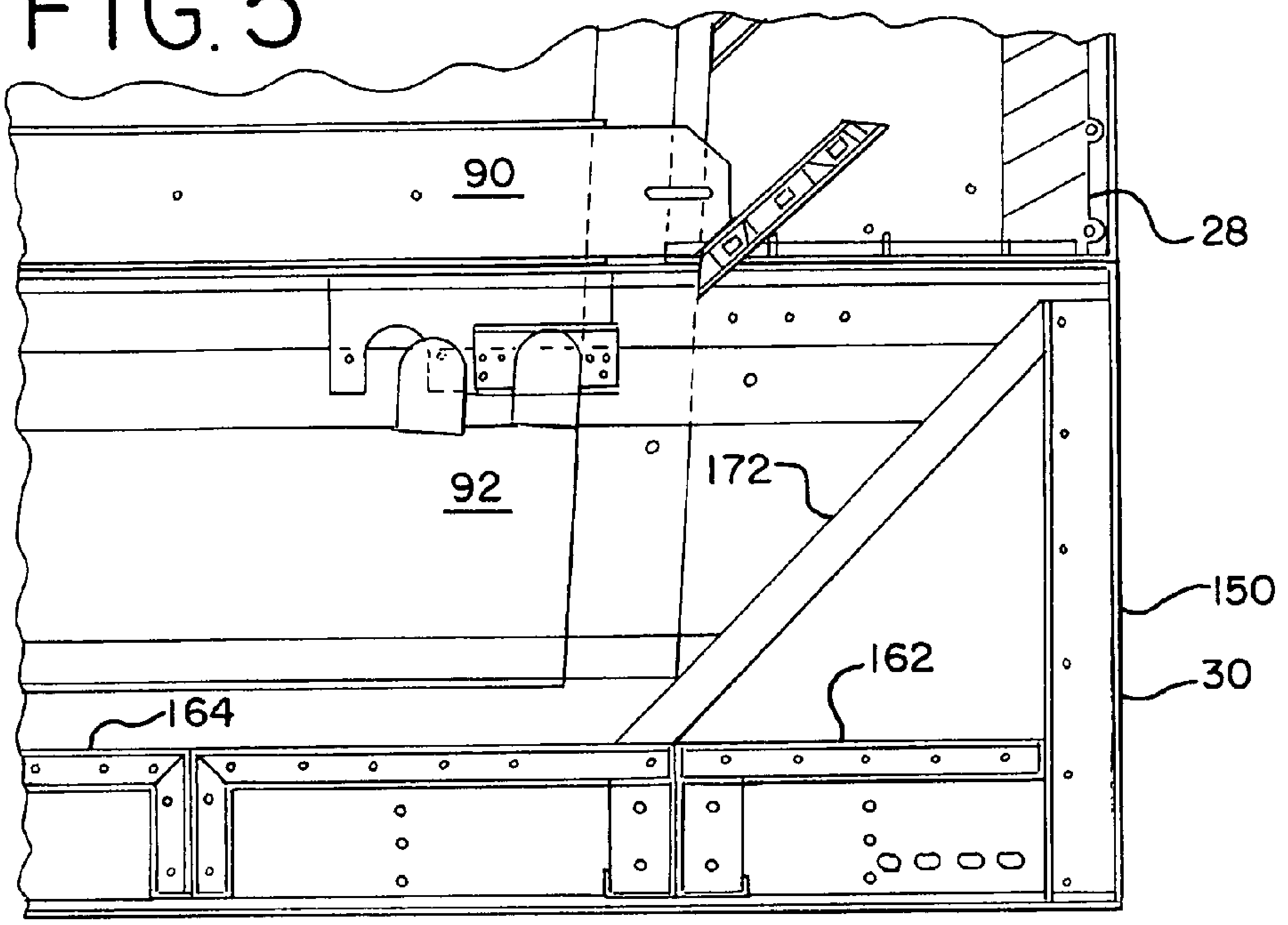
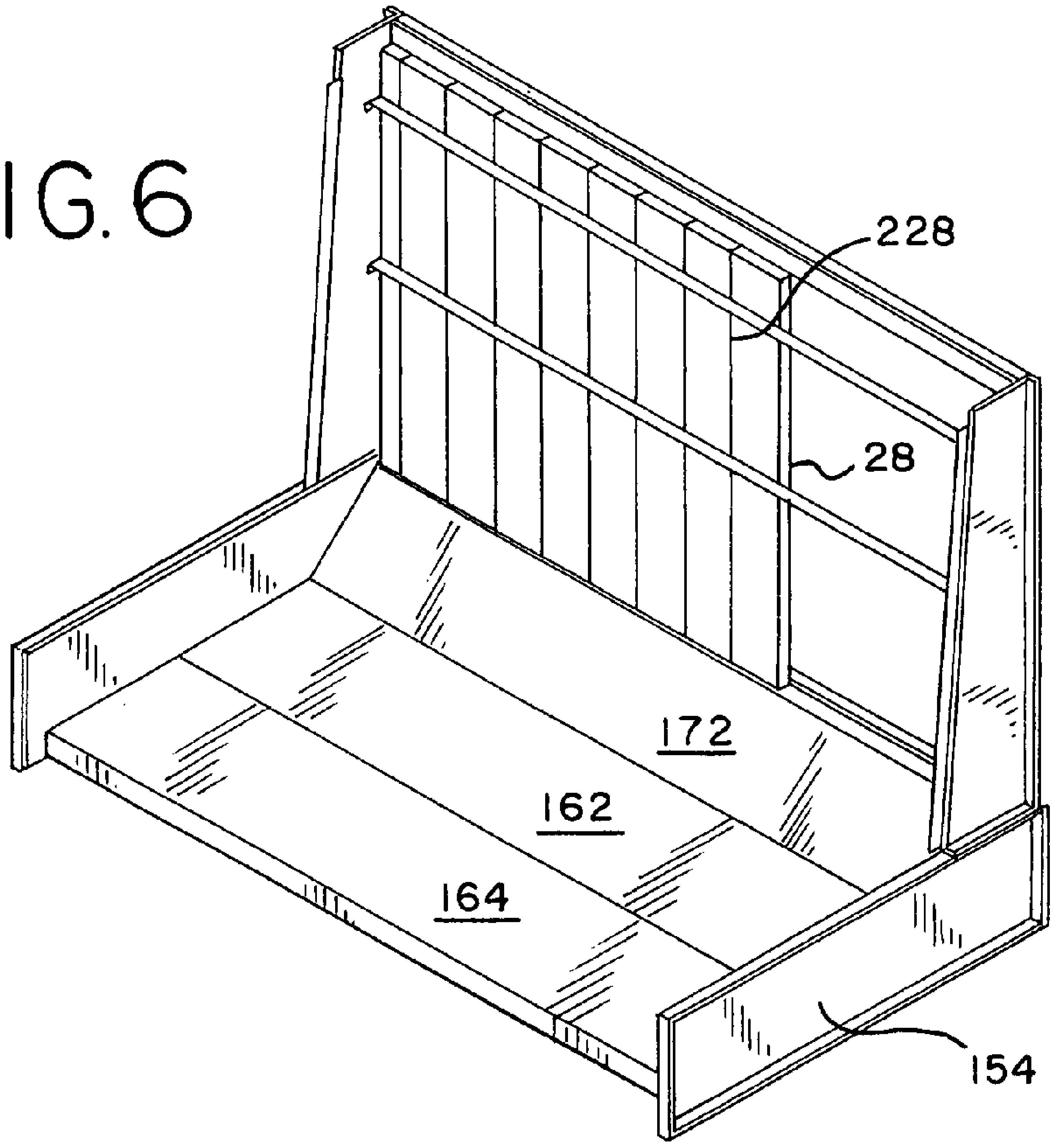


FIG. 6



COOLING TOWER AIR INLET AND DRAIN PAN

BACKGROUND OF INVENTION

The present invention relates generally to cooling towers and, more specifically, to a cross flow evaporative heat and mass exchanger used for evaporative fluid cooling. The cross flow arrangement could be a single side or double side entry apparatus. Further, the cooling tower could comprise both a direct fluid cooling arrangement wherein air is passed over fill through which falling liquid is passed thereby cooling the liquid and an indirect cooling section wherein a fluid is passed through a coil and cooled by the liquid, usually water, falling downwardly across the coil thereby providing indirect cooling to a liquid or a gas passing through the coil.

In an induced draft single cross flow or double cross flow cooling tower, a fan is mounted on the roof outlet of the tower. This fan draws or induces air flow inwardly into the cooling tower through a sidewall or opposite sidewalls of the tower. Water or other evaporative liquid to be cooled is pumped to the top of the cooling tower structure and distributed through a series of spray nozzles. These spray nozzles emit a diffused spray of the water across the top of an appropriately selected fill medium. Such fill most typically comprised of a bundle of generally spaced parallel plastic sheets across each of which the water spray is dispersed and downwardly passed by gravity. A large surface area across which the water is dispersed on such sheets leads to good cooling by the induced air flow over such sheets. The cooled water is collected in a drain pan or sump and passed through to the desired cooling system wherein it will become heated and then pumped back to the cooling tower.

As mentioned above, the addition of an indirect cooling section in the form of a series of serpentine heat exchange conduits can be provided either above or below the fill sheets. A hot fluid or gas to be cooled or condensed enters the heat exchange conduits through an inlet header at one end of the conduits with the cool fluid exiting the conduit through a header joining the other ends of the conduit.

A concern in such cross flow cooling towers is the accumulation of algae or other biological contaminates in the drain pan. Such accumulation is usually due to incomplete flow of water through the drain pan. Such development of algae and other biological contaminates is increased with the exposure to sunlight. As the sump or drain pan must catch all flowing water from the cooling section, the design of such sump must address the both collection and drain needs to assure flow of all collected water from the sump to the drain outlet. Water treatment chemicals are used in the cooling tower sump to decrease the accumulation of such biological contaminates, but the design of the cooling tower sump and air inlet themselves can improve the resistance of the tower to forming such biological contaminates. Airborne debris that passes through the typical louver arrangement in the air inlet side or sides of the cross flow cooling tower can also contribute to the development of the biological contaminates. Accordingly, an improved design of the air inlet to eliminate of in flow of such airborne debris is also part of the present invention.

SUMMARY OF INVENTION

It is an object of the present invention to provide an improved cooling tower using a cross flow air flow relationship with an improved drain sump design.

It is also an object of the present invention to provide a cooling tower utilizing a cross flow air arrangement with an improved air inlet apparatus to decrease the potential for airborne debris to enter the tower.

In a mechanical draft cooling tower of the induced draft cross flow type using a single air entry side or two air entry sides with a single fan plenum chamber above the air inlet passages, the water spray downwardly onto the fill bundle spreads and trickles down the fill sheets. The water is cooled by the air flow across the fill sheet themselves.

In such cooling towers, in accordance with the present invention, it is also possible to provide an indirect cooling section wherein a tubular coil heat exchanger comprising a plurality of coil assemblies is provided above or below each fill bundle. The water falling from the direct and indirect cooling sections is collected in a drain sump. In order to assure the complete flow of such collected water through such sump, the ends of the sump are sloped to assure that such water is not collected in a stagnant area of the sump. It should be understood that each such sump is usually rectangular, having two ends and two generally longer sides. Steeply sloped internal wall ends aid in assuring the flow of water in the sump to avoid stagnation. Such steeply sloped sides do not detract from the entry of air through the inlets across the fill, but yet allow the water entering the drain pan to completely flow without collection in any possible stagnant area.

It is also part of the present invention to provide an improved design of louvers to the air inlet space of the cooling tower. Such improved louvers are generally of a honeycomb arrangement which lessen the potential for airborne particles or debris to enter the water falling across the cooling tower fill and enter the collection sump.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings,

FIG. **1** is a side view of an embodiment of a cooing tower of the present invention having a single coil indirect evaporative heat exchange section and a direct heat exchange section;

FIG. **2** is a side view of a second embodiment of the present invention having a dual air inlet cooling tower with two indirect and direct sections;

FIG. **3** is a perspective view of a cooling tower in accordance with an embodiment of the present invention having dual direct cooling sections;

FIG. **4** is a perspective view of the improved drain sump of an embodiment of the present invention;

FIG. **5** is a detailed sectional and partial cross section of the improved slope basin and the improved air inlet of an embodiment of the present invention, and

FIG. **6** is a detailed partial view of an improved air inlet of an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring not to FIG. **1** of the drawings, the heat exchange apparatus **10** in accordance with the invention is shown as a closed-circuit cooling tower. Generally, apparatus **10** includes an enclosure structure which contains a multi-circuit indirect evaporative fluid cooling section **50**, a direct evaporative heat exchange section **90**, a lowermost evaporative liquid collection sump **30**, and an uppermost distribution means **36** for spraying an evaporative liquid downwardly through apparatus **10**, and a fan means **24** for moving a stream of air through each of the heat exchange sections **50** and **90**, although natural draft is also a viable means for moving the air. Fan **24** can either be induced or forced draft centrifugal fan or a common propeller type fan, any of said fan choices requiring fan motor **25** to power them. Again referring to FIG. **1**, motor **25** can be mounted within enclosure passageway **15** if an appropriate wet condition motor casing or a protective cover is used, or it can be mounted on the outside of the structure if desired. Here it is shown in the air stream in moisture proof box **200**.

It is important to understand that apparatus **10** has many applications in the heat exchange field and that each application will use all of the same above-mentioned elements, although the operation of those elements might vary slightly from one type of application to the other. For example, apparatus **10** may be used to cool a single phase, sensible fluid such as water, which is flowing within an externally-supplied closed circuit system, or it may be sued to desuperheat and condense a multi-phase, sensible and latent fluid such as a refrigerant gas, also supplied from an external closed-circuit system.

In accordance with one embodiment of the present invention illustrated in FIG. **1**, the enclosure structure comprising apparatus **10** is shown with a generally rectangular shape which includes an upper roof surface **12**, a base **18**, a front wall **14**, a rear wall **16**, a first side wall **20** and a second side wall **22**. The side walls **20**, **22** and rear wall **16** are continuously solid panel members made from materials such a sheet metal, fiberglass, plastic, or the like, and these walls have corrosion resistant properties as does front wall **14** and roof surface **12**.

The rectangular enclosure structure of FIG. **1** contains an indirect heat exchange section **50**, which is comprised of a single coil assembly **52**, superposed above the direct evaporative heat exchange section **90**. The indirect heat exchange section **50** is typically of a rectangular shape, having an inboard side **51**, an outboard side **57**, a top side **53** and a bottom side **55**. The indirect heat exchange section coil assembly **52** receives a flowing hot fluid to be cooled from an offsite process, and it is cooled in this section by a combination of indirect sensible heat exchange and a direct evaporative heat exchange. The evaporative liquid, which is usually cooling water, is sprayed downwardly by distribution means **36** onto the indirect section, thereby exchanging indirect sensible heat with the fluid to be cooled, while the stream of ambient air entering primary air inlet **100**, evaporatively cools the water as the two mediums move downwardly through coil system **52**. In this particular embodiment the entering air stream is shown entering and flowing in a direction which is parallel or concurrent with the direction of cooling water, although the air flow stream is not limited to any particular flow pattern, as will become evident later on where a crosscurrent air flow pattern will be explained. Once the air and water cooling mediums reach bottom side **55** of indirect section **50**, they split, with the air system being pulled into plenum **105** and then into passageway **15** by fan **24**, while the water gravitationally descends into direct heat exchange section **90**. The air is then discharged from apparatus **10** through the fan cylinder **26** while the water is cooled in the direct heat exchange section as will be explained shortly. It is also important to note that the air stream entering inlet **100** supplies air that will only be used for cooling purposes in the indirect heat exchange section, regardless of the actual air flow pattern through said section.

The direct evaporative heat exchange section **90** functions to cool the water that is heated and descending from the indirect heat exchange section **50**. Direct evaporative heat exchange **90** is comprised of an array of tightly-spaced, parallel, plastic sheets **93** which form fill bundle **92**. The hot water received by fill bundle **92** from indirect section **50** is distributed across each fill sheet **93** so that a source of outside ambient air which enters secondary air inlet **102**, evaporatively cools the hot water descending the sheets. Here, the ambient air stream is shown entering direct section **90** in a crosscurrent fashion to the descending hot water draining through the fill bundle **92**, although other air flow schemes can be used, as will be seen later. The plastic fill sheets **93** are usually hung from beams **96** that are connected to and traverse sidewalls **20** and **22**. Each sheet **93** has a generally continuous, waved pattern of grooves running the entire length of the sheet to aid in spreading the downflowing hot water into a thin film, thereby providing a larger exposed surface area for the air stream to interact with and evaporatively cool. Fill sheets **93** are preferably made from a polyvinyl chloride material, although other types of plastics could be used. Secondary ambient air inlet **102** provides ambient air that is strictly dedicated for evaporative cooling purposes in the direct heat exchange section only.

As further seen from FIG. **1** a secondary entryway **102** is covered with a honeycombed structure **28**. Such honeycombed structure **28** is an improvement over the typical louver arrangement. Such honeycomb structure includes openings that readily allow air flow but keep air borne debris from entering indirect cooling tower **90** and fill bundle **92**. This honeycomb design is further described in FIGS. **5** and **6** below. The ambient air entering through honeycomb **28** initially flows across the secondary air plenum **103** before entering fill bundle **92** in a crosswise or crosscurrent fashion to the hot water downwardly gravitating through the plastic fill sheets **93**. As mentioned, the stream of cold air passing over the film of hot water evaporatively removes heat from the water, thereby cooling the hot water by well known evaporative effects. The heated air existing evaporative cooling section **90** then passes through secondary drift eliminator **49** before entering passageway **15**, where it is forced by fan **24** to upwardly change directions for discharge to the atmosphere through fan cylinder **26**. Since the air leaving the direct water evaporative cooling section **90** becomes saturated with moisture absorbed from the cooling water, the secondary drift eliminator **49** is interposed between the fill bundle **92** and passageway **15** to facilitate in removing the water droplets entrapped in the air stream. Drift eliminator **49** it typically comprised of closely spaced metal, plastic or wood slats or louvers which permit air flow thererthrough, but will collect the fine water droplets in the air. The collected water then gravitates down eliminator **49**, directly into underlying collection sump **30** for recirculation.

As seen in FIG. **1**, the entire base **18** of apparatus **10** is substantially comprised of a water collection sump **30** which is typically disposed only below direct evaporative heat exchange section **90**, although it truly depends upon how the components are arranged within the structure of apparatus **10**, where the direct and indirect sections are side-by-side. The side-by-side or indirect-over-direct arrangements merely emphasize that the most important feature of the present invention is that the heated cooling water descending from the direct evaporative heat exchange section **90** is allowed to mix in sump **30** so that it can attain a uniform temperature before being pumped for use again in the indirect heat exchanger section **50**. As seen, vertically extending recycle piping **34** operably connects cooling water distribution means **36** with pump **32** and sump **30**. Pump **32** is arranged outside of sump **30** near the corner of front wall **14** so that it can be easily serviced.

Distribution means **36** is generally located above the single coil assembly **52** of indirect evaporative cooling section **50**, which is also in positional relationship with primary ambient air inlet **100**. Distribution means **36** consists of identical cooling water distribution legs **38** and **40**, each of which laterally transverse the width of tower **10** in a spaced, parallel relationship from each other and from front wall **14**. Each distribution leg **38** and **40** is constructed from pipe and has a series of equidistantly spaced spray nozzles **46** attached along the bottom of the pipe for evenly distributing the cooling water across the top side **53** of indirect evaporative heat exchange section **50** and generally across the primary air inlet **100**. Depending upon the heat exchange capacity required from apparatus **10**, the number of water distribution legs can vary from 1 to 5 legs per indirect evaporative coil section **52**, with the length of each leg varying between 3-24 feet. Typically, the number of nozzles **46** per coil assembly **52** of indirect section **50** will vary between 9-180 nozzles, also depending upon the tower capacity. Likewise, pump **32** is sized according to tower capacity such that the continuous supply of cooling water pumped to spray nozzles **46** will produce a fine spray of water across the entire span of the primary air inlet **100** and hence, across the single coil assembly **52**. Similarly, an upper drift eliminator **48** is interposed between side outlet opening **106**, plenum **105** and passageway **15** to remove the water droplets entrapped by the primary air stream while evaporatively cooling the water descending through indirect heat exchange section **50**. Pan **47** is disposed below upper drift eliminator **48** for collecting the water from mist eliminator **48** and gravitationally dispensing it upon fill sheet bundle **92**. It is to be understood that the opening which defines primary ambient air inlet **100** has a dimensional length and width equal to that of the indirect evaporative cooling section **50** no matter where the entry is located. From FIG. **1** it is seen that the entering air stream initially approaches entryway **100** generally perpendicular to the top side **53** of indirect heat exchange section **50**, substantially concurrent with the water sprayed downwardly from distribution means **36**.

Referring now to FIG. **2** of the drawings, a series flow, dual coiled assembly **52** and **52**A is incorporated into apparatus **10** with a split cooling water system. This apparatus is generally known in the art as a closed loop, double coiled cooling tower and represents the preferred dual coiled embodiment. Each of the tower ends **6** and **8** contain the exact same elements within each respective tower half as are contained within the structure of the single coiled, preferred embodiment of FIG. **1**. As seen, the hot fluid to be cooled is initially supplied to the first tower end **6** through supply piping **75**W. the hot fluid generally enters and travels upwardly as previously explained for the single coiled apparatus, however, instead of exiting indirect heat exchange section **50** and returning to the offsite process, the fluid leaves indirect section **50** through piping **85**W and is communicated to the inlet header **75***a* on the second indirect coil assembly **52***a* of the second indirect heat exchange section **50**A of tower half **8**. Once again, the fluid travels upwardly through indirect heat exchange section piping **52***a* and cooling capacity is further increased by an additional 10% as compared to the same unit with the heat exchange sections piped in parallel. Once cooled within indirect heat exchange section piping **52***a*, the fluid is then returned to the offsite process through discharge piping **85**C. All methods of heat exchange within each of the heat exchange sections on each tower half **6** and **8** are exactly the same as those previously described with the single coil operation, except that the cooling water systems for each tower half **6**, **8** operate separately, with each tower half **6**, **8** having its own sump, **30** and **30**A, and its own cooling water distribution system.

Referring now to FIG. **3** of the drawings, an embodiment of the present invention is shown in a perspective view. This perspective view is similarly numbered features of FIG. **2** are set forth in FIG. **3**, and will not be described in detail here. Indirect heat exchange section is shown generally at **50**, although it should be understood that the features of the present invention could apply to a cooling tower that does not include an indirect heat exchange section. A direct heat exchange section **90** is seen to include fill sheet bundle **92** which is visible with part of honeycomb inlet **28** broken away to show portion of fill sheet **92**. Further, collection basin is shown generally at **30** which will be described further. Collection basin **30** is seen to be generally rectangular in shape, having ends **150** and **152**, with sides **154** and **156**.

Referring now to FIG. **4**, basin or sump **30** is shown in detail as a generally rectangular structure having ends **150** and **152** with sides **154** and **156** forming a generally rectangular, pan like structure. Most typically, sump **30** is comprised of galvanized steel, but can be comprised of aluminum or stainless steel. Bottom **160** is seen to be comprised of a series of sections **162**, **164**, and **166** which are seen to be inclined downwardly toward center **168** on one side of sump **30**. Similar sections are on the other side of sump **30**. A drain exits from center sump section **168**.

In order to decrease the possibility of biological contaminates such as algae building up in sump **30** while it holds water drain from direct cooling tower section **90**, inclined internal end walls **170** and **172** are provided on the internal surface of sump **30**. Such inclined internal end walls **170** and **172** extend the entire width of sump **30** in this embodiment, and the presence of such inclined end walls acts to ensure the movement of all water that enters sump **30** toward lower most center sump sections **168** to assure the elimination of any possibility of stagnation of such water in sump **30**. This greatly reduces the possibility of formation biological contamination such as algae in the water held in sump **33**.

Referring now to FIG. **5** of the drawings, a detailed end view, in partial cross section, is shown of sump **30**. Sump **30** is seen to be comprised of an end wall **150**, with internal inclined wall **172** forming part of the actual collection section of sump **30**. It is seen that fill **92** may extend downwardly into sump **30**. Further, the slight incline of bottom section **162** is seen to be extended to adjacent bottom sump section **164** to assure a downwardly flow and collection of waters entering sump **30** toward center lower most sump section **168**. Further, it is seen that the angled incline of internal sump end section **172** greatly reduces the possibility of any stagnation or collection of water within sump **30** that would not be moved toward center lower most section **168** and outwardly through the drain in sump **30**. The preferred angle of internal sump end wall **172** is about 35°, with angles from 25 to 60° being functional as well.

Also shown in FIGS. **5** and **6** is a view of honeycomb end wall inlet **28**. It is seen that such structure, which is generally of fiberglass, provides a ready inlet of air into indirect cooling section **90** and fill **92**. Such honeycomb structure **28** is seen to greatly reduce the potential for airborne debris to enter direct cooling section **90**. Honeycomb structure **28** is comprised of a plurality of vertically aligned slats **228** that have openings therein to allow the passage of air therethrough yet block the passage of airborne debris.

What is claimed is:

1. A mechanical draft direct and indirect cooling tower comprising

at least one direct section having a plurality of fill sheets wherein a fluid is distributed over the fill sheets,

a fan to draw air into the cooling tower across the fill sheets thus cooling the fluid flowing over the fill sheets,

the fluid distributed over the fill sheets falling from the fill sheets into a collection sump,

the collection sump having a generally rectangular configuration with two parallel end walls and two parallel side walls, a sloped floor with at least two different slopes, and a drain, wherein the sloped floor has a compound slope at least one end wall and is in contact with the side walls such that a significant portion of the compound sloped floor includes a first part located above an operating sump water level and wherein the sloped floor in the first part is sloped to prevent the settling of dirt and debris,

further comprising a second part of the compound slope floor sloped towards a drain but at a lesser angle from the horizontal than the first part of the compound slope floor.

2. The cooling tower of claim **1**

wherein the first part of the sloped floor is sloped 25 to 70° from the horizontal.

3. The cooling tower of claim **1**

wherein the first part of the sloped floor is sloped 40 to 60° from the horizontal.

4. The cooling tower of claim **1**

wherein at the operating sump water level, less than three inches of horizontal water surface prior to the air entrance to the fill section is located above the surface of the first part of the compound slope floor.

5. The cooling tower of claim **1**

wherein a louver arrangement is provided through which air is drawn into the cooling tower, the louver arrangement comprising aligned slats that block the passage of airborne debris and sunlight into the cooling tower.

6. A mechanical draft cooling tower comprising

at least one direct cooling section having a plurality of fill sheets wherein a fluid is distributed to flow over the fill sheets,

a fan to draw air through an air inlet into the cooling tower across the fill sheets thus cooling the fluid flowing over the fill sheets,

the fluid distributed over the fill sheets falling from the fill sheets into a collection sump,

the collection sump having a generally rectangular configuration with two parallel end walls and two parallel side walls, a sloped floor with a least two different slopes, and a drain, wherein the sloped floor has a compound slope at least one end wall and is in contact with the side walls such that a significant portion of the compound sloped floor includes a first part in front of the air inlet located above an operating sump water level and wherein the sloped floor in the first part of the compound sloped floor is sloped to prevent the settling of dirt and debris, further comprising a second part of the compound slope floor sloped towards a drain but at a lesser angle from the horizontal than the first part of the compound slope floor.

7. The cooling tower of claim **6**

wherein the first part of the compound sloped floor is sloped 25 to 70° from the horizontal.

8. The cooling tower of claim **6**

wherein the first part of the sloped floor is sloped 40 to 60° from the horizontal.

9. The cooling tower of claim **6**

wherein at the operating sump water level, less than three inches of horizontal water surface prior to the air entrance to the fill section is located above the surface of the first part of the compound slope floor.

10. The cooling tower of claim **6**

wherein a louver arrangement is provided through which air is drawn into the cooling tower, the louver arrangement comprising aligned slats that block the passage of airborne debris and sunlight into the cooling tower.

* * * * *